In light of the functional requirements and performance limitations, the performance and interference criteria adopted internationally for meteorological satellite services are specified for elevation angles of five (5) degrees and higher. Specifically, for the 137-138 MHz and 400.15 - 401 MHz bands, Recommendation ITU-R-SA.1025-1 specifies a meteorological satellite performance objectives for 99.9% of the time that the elevation angle exceeds five (5) degrees. For protection of these transmissions, Recommendation ITU-R SA.1026-1 specifies that the total interfering signal power should not exceed certain levels during reception at elevation angles exceeding five (5) degrees. Both of these Recommendations were based on United States input documents to the ITU Working Party 7C, which were endorsed by the worlds meteorological satellite experts.

We agree that the flux density from any of the FDMA Little LEO applicants may result in unacceptable interference to NOAA user terminal operation whenever the Little LEO satellite is within the line of sight to the NOAA terminal and that terminal is receiving a NOAA downlink transmission on the same frequency. This is due in part to the use of NOAA terminal hemispherical receiving antenna coverage patterns (These patterns typically fall off rapidly near the horizon). Again, NOAA transmissions cannot be reliably received below 5° to 10° elevation due to multipath and local obscura just as a Little LEO's transmissions would not be reliably received. Thus, a 0° Little LEO footprint overlap with a 5° NOAA satellite coverage footprint would seem appropriate for the calculation of a Little LEO exclusion zone, consistent with the frequency sharing criteria adopted internationally for meteorological-satellite earth station receivers.

Requiring a 0° Little LEO footprint to 0° NOAA satellite coverage exclusion zone would be excessive. This directly impacts the Little LEO commercial service availability. The typical impact to Leo One USA using the NOAA bands is summarized in Table 2. For instance, the difference to Leo One USA of a 0° to 0° coverage exclusion zone and 5° NOAA to 0° Leo One USA coverage exclusion zone is computed as reducing the availability from 77% to 68%.

Blockage of the NOAA channels is computed here as occurring when ever there are two NOAA satellites overlapping a Leo One USA satellite coverage; this is under the worse case assumption that the NOAA satellites traveling in close proximity will use differing NOAA channels (and, thus, both available channels). It is also assumed that the frequencies used by the NOAA satellites and their ephemeris will be published by NOAA and made available so that any Little LEO operating in this band can use alternative frequency bands when a singular NOAA satellite is within its horizon footprint. Figure 6 is a plot of the Leo One USA availability as a function of Latitude. For this analysis, five DMSP satellites currently in orbit have been used to define a future prototypical 5 satellite constellation. The Leo One USA operational coverage is here defined as 15° acquisition elevation angle.

Table 1 Availability Impact Of Exclusion Zone To LEO-One @ 40° Latitude.

Exclusion Zone	Constellation Availability
None	100%
0° Leo One to 10° NOAA	84%
0° Leo One to 5° NOAA	**77%**
0° Leo One to 0° NOAA	68%

15° Leo One Acquisition Angle

The difference in the size of the exclusion zone coverage for 0, 5 and 10 degree elevation angles is shown in Figure 7, Figure and Figure . The size of the exclusion zone increases by nearly 15% for a decrease in NOAA elevation angle from 5° to 0°.

Leo One USA believes a 5 degree NOAA operational coverage zone to a 0° Leo One USA coverage footprint is a reasonable requirement.

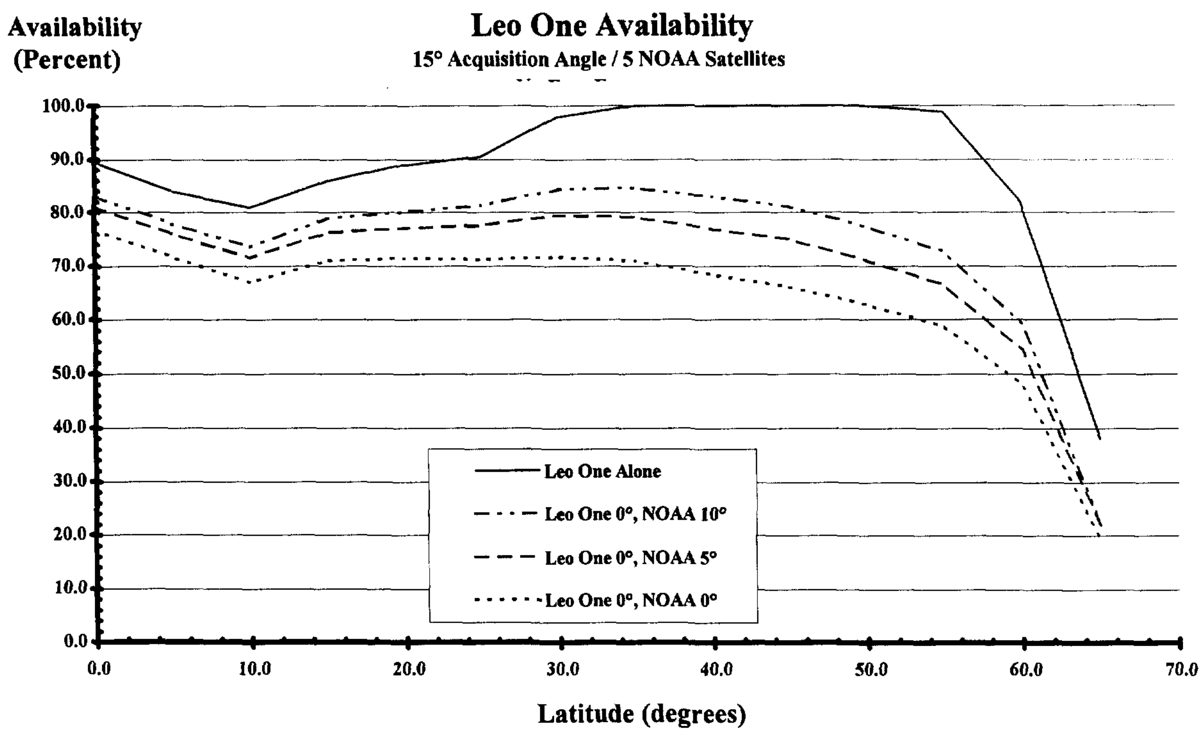

Figure 6. Leo One USA Availability For 0, 5 and 10 Degree NOAA Coverage With 0 Degree Leo One USA Coverage Avoidance.

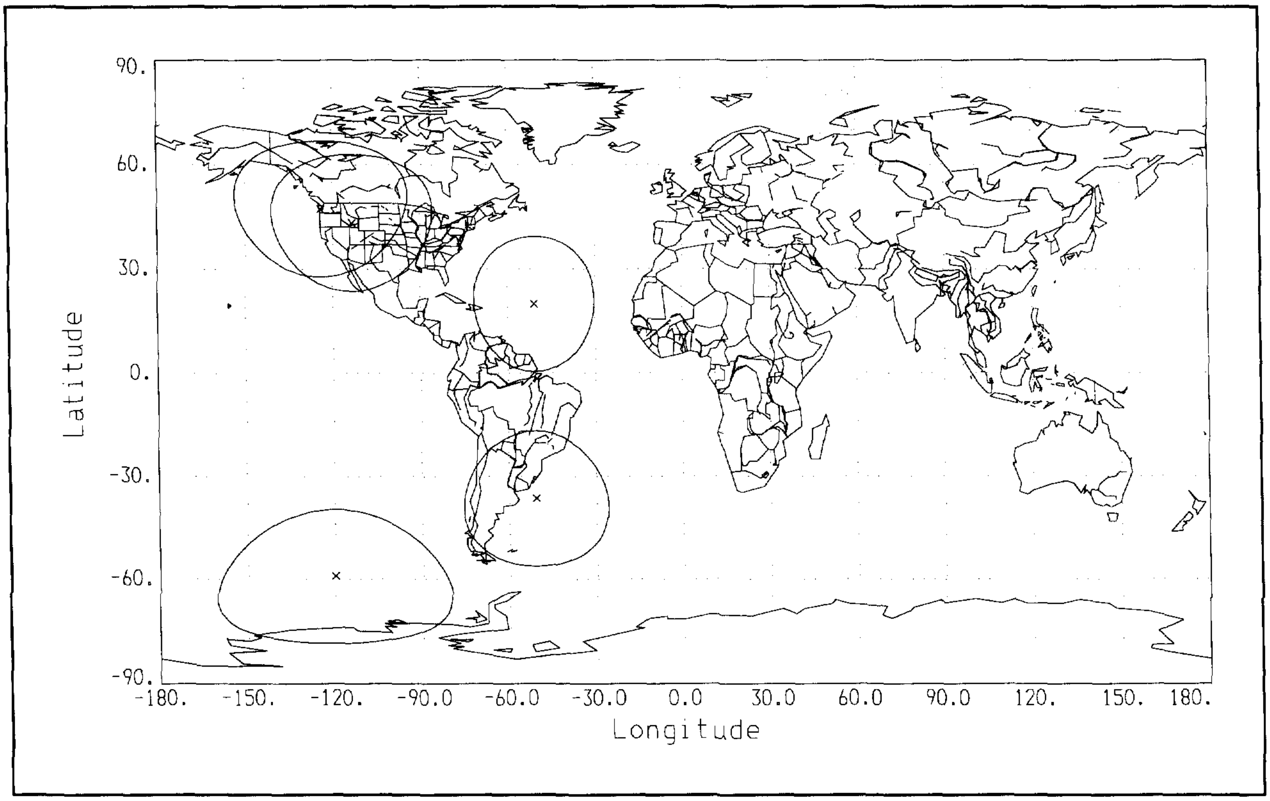

Figure 7. NOAA Coverage Footprint For 10 Degree Elevation.

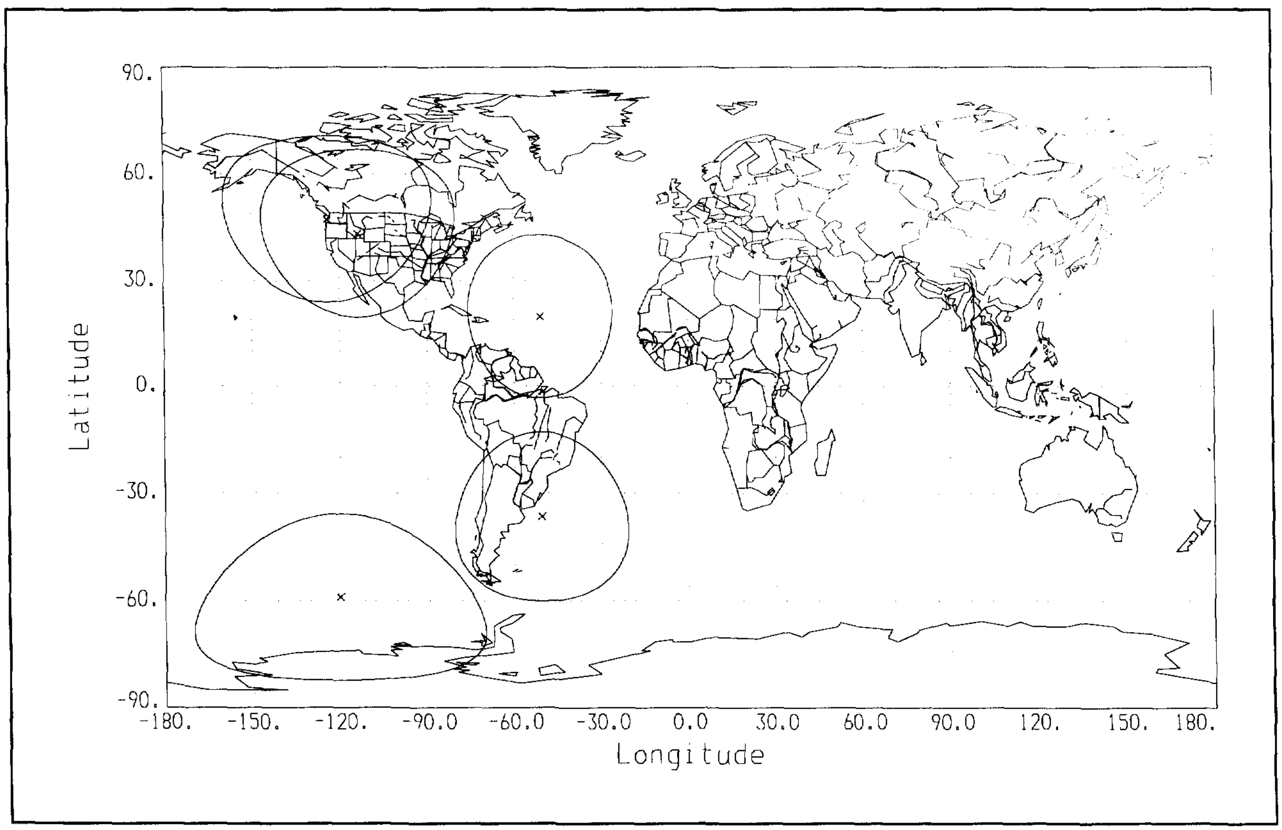

Figure 8. NOAA Coverage Footprint For 5 Degree Elevation.

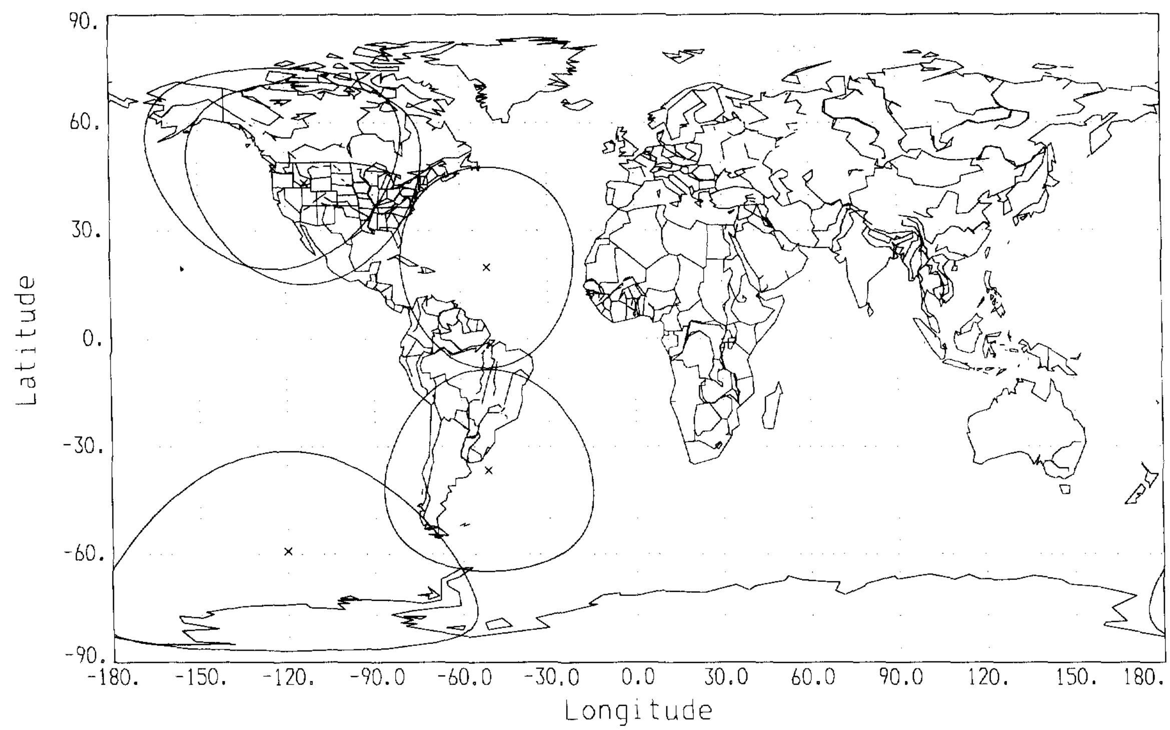

Figure 9. NOAA Coverage Footprint For 0 Degree Elevation.

2. <u>Sharing with DMSP MetSats in the 400.15 - 401 MHz Band</u>

The DMSP MetSat band can be shared on a non-interference basis to DMSP using a frequency avoidance concept. This simplified frequency sharing concept requires the Little LEO satellites to step or hop to the opposite DMSP MetSat band segment whenever a MetSat coverage footprint overlaps that of a Little LEO satellite horizon. The coincidence times are readily precomputed and frequency selection instructions can be loaded into each satellite to span the duration of element set validity.

It should be noted that for a five satellite DMSP system, the potential exists for two DMSP coverage zones to overlap a Little LEO horizon footprint as shown in Figure 10 over CONUS. These coverage contours were obtained by using five of the DMSP satellites currently in orbit as representative of future orbital coverage. This overlap will result in total blockage of the Little LEO System in those areas where the dual DMSP overlap occurs. Worse still, any two DMSP satellites within the horizon coverage of a Little LEO satellite will potentially result in a blockage situation. This worse case analysis assumes the two DMSP MetSats in close proximity will use both portions of the band so as not to interfere with themselves, leaving Leo One USA without any available spectrum during this overlap period.

Under the assumption that the DMSP downlink frequencies in use will be provided to the Little LEO operator, it is possible to estimate user availability for the band hopping approach described. The availability to Leo One USA users is a function of the exclusion zone size as discussed in the response to Notice at Paragraphs 61 and 71. Table 2 provides a summary of the impact of the exclusion zone elevation angle impact to availability. Figure 11 shows the availability as a function of latitude.

Table 2. LEO-One Availability @ 40° Latitude.

Exclusion Zone	Constellation Availability
None	*100%*
0° Leo One to 10° DMSP	84%
0° Leo One to 5° DMSP	77%
0° Leo One to 0° DMSP	68%

15° Leo One Coverage Angle

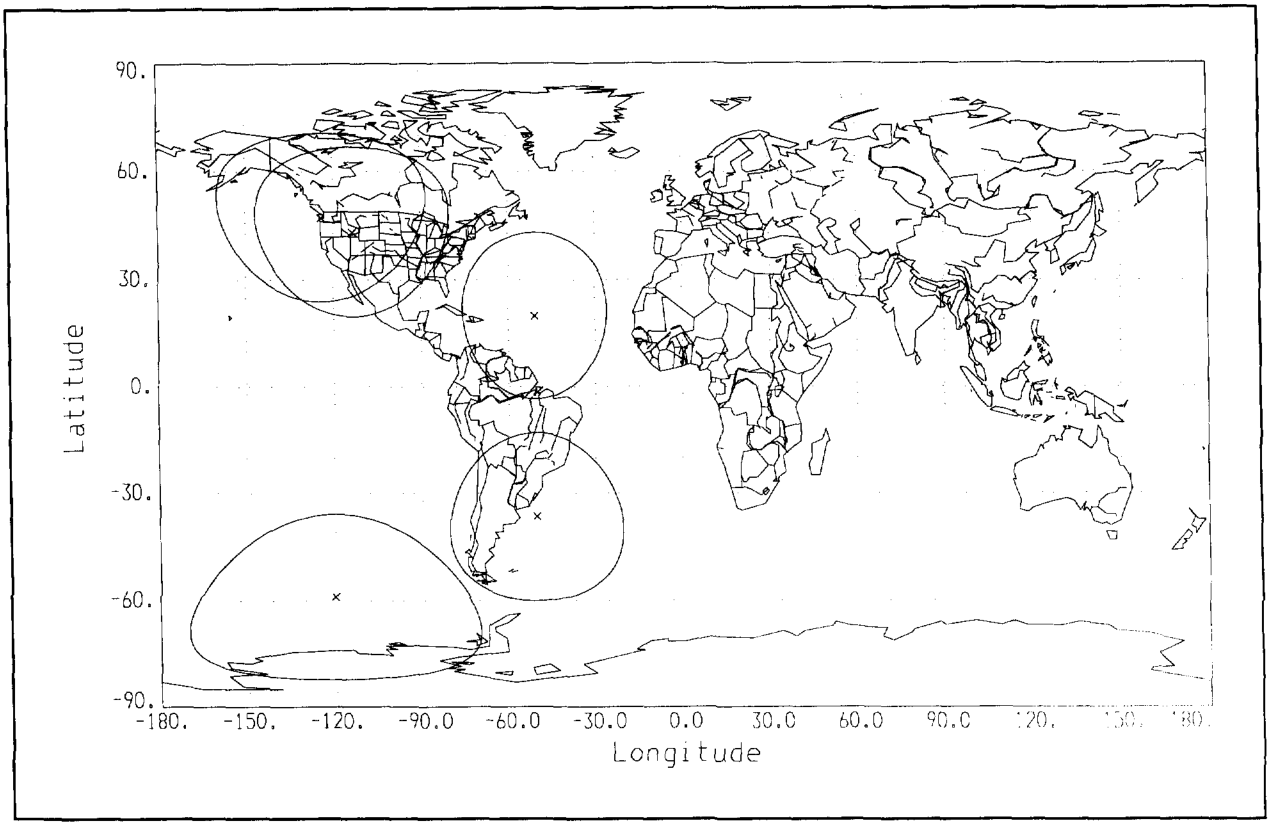

Figure 10. DMSP Five Satellite Constellation Coverage For 5° Elevation Footprint.

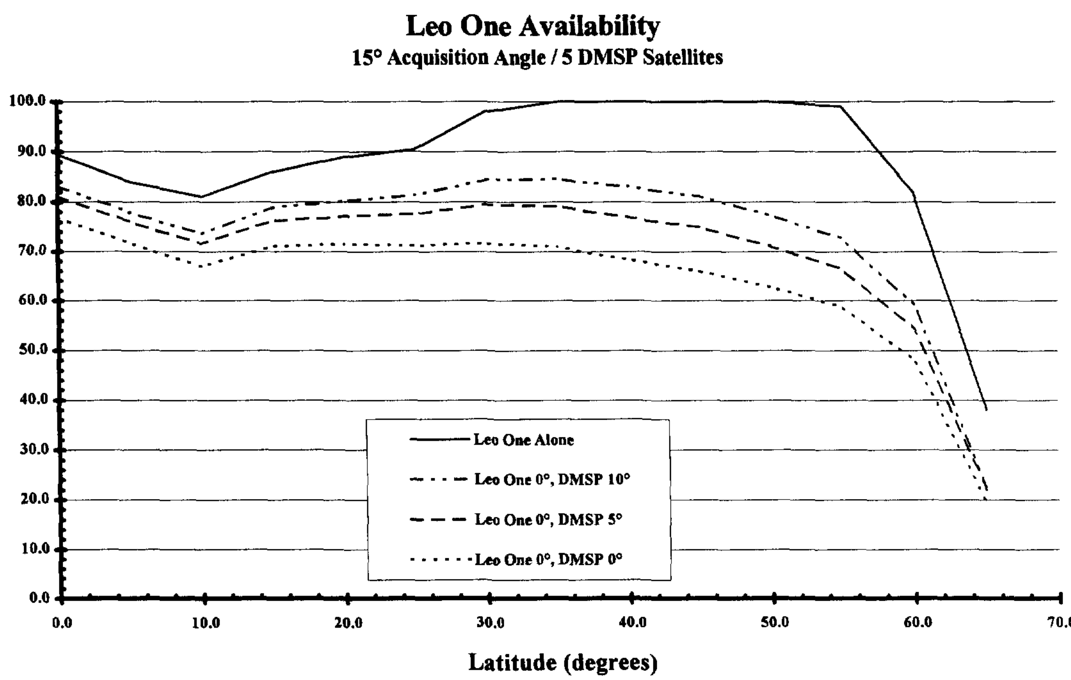

Figure 11. Availability For 15° Leo One USA Coverage, 5 DMSP MetSats.

As the above material demonstrates, the requirement for near real time service cannot be realized by Little LEO System 3.

A. DMSP Earth Stations Operating in the 400.15 - 401 MHz band Should be Protected Only While Associated Satellites are Located at Elevation Angles of Five Degrees or Greater

Protection of DoD MetSats below 0° elevation angle is not warranted. Even zero degrees is beyond any operational requirements and capabilities of the DMSP satellites and their ground terminals. On the other hand, the impact to a Little LEO availability is significant. For instance, not only do the NOAA/DMSP orbits coincide with the daylight busy hours of each region, in many cases the satellite are traveling in close proximity to each other. This has the effect of potentially blocking both the DoD downlink bands at 400 MHz. Figure shows such a case where two DMSP satellites are over CONUS. This plot is for 10 degree elevation coverage contours. Figure shows the increased coverage and blockage for 5 degree coverage while Figure shows the increased coverage at 0 degrees elevation angle. The denied Little LEO coverage area increases by 40 percent from 10° to 0° coverage. This increase is of the order of 15% for 5° to 0° degrees coverage zones. As described in Appendix D, DMSP operation below 10 degrees is marginal and below 5 degrees is unlikely. Leo One USA believes a 5 degree DoD/DMSP operational coverage zone to a 0° Leo One USA coverage footprint is a reasonable requirement. If any Little LEO is to make use of these band, it is also reasonable that the DoD provide the frequencies use by each satellite and its ephemeris such that the Little LEO satellite operator can use those frequencies that are not in conflict with those DoD/DMSP satellites that overlap its coverage.

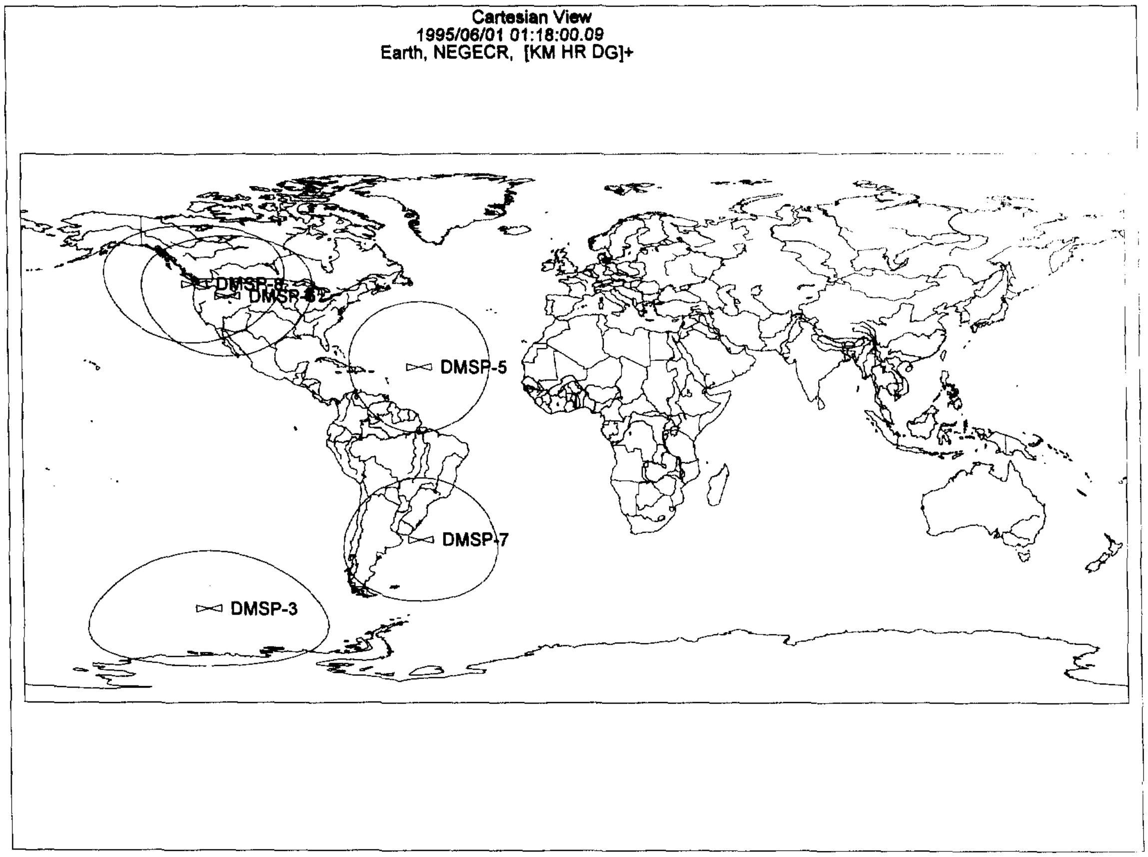

Figure 12. DMSP Coverage Footprint For 10 Degree Elevation.

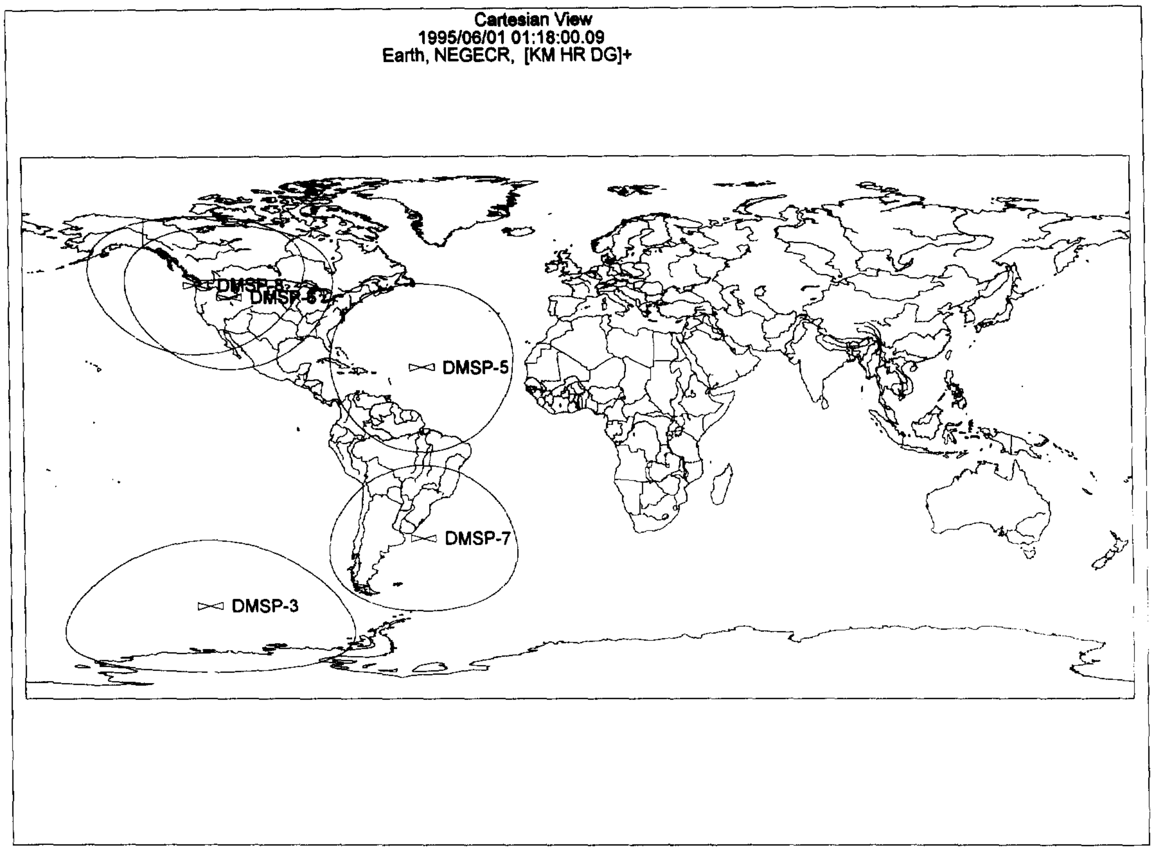

Figure 13. DMSP Coverage Footprint For 5 Degree Elevation.

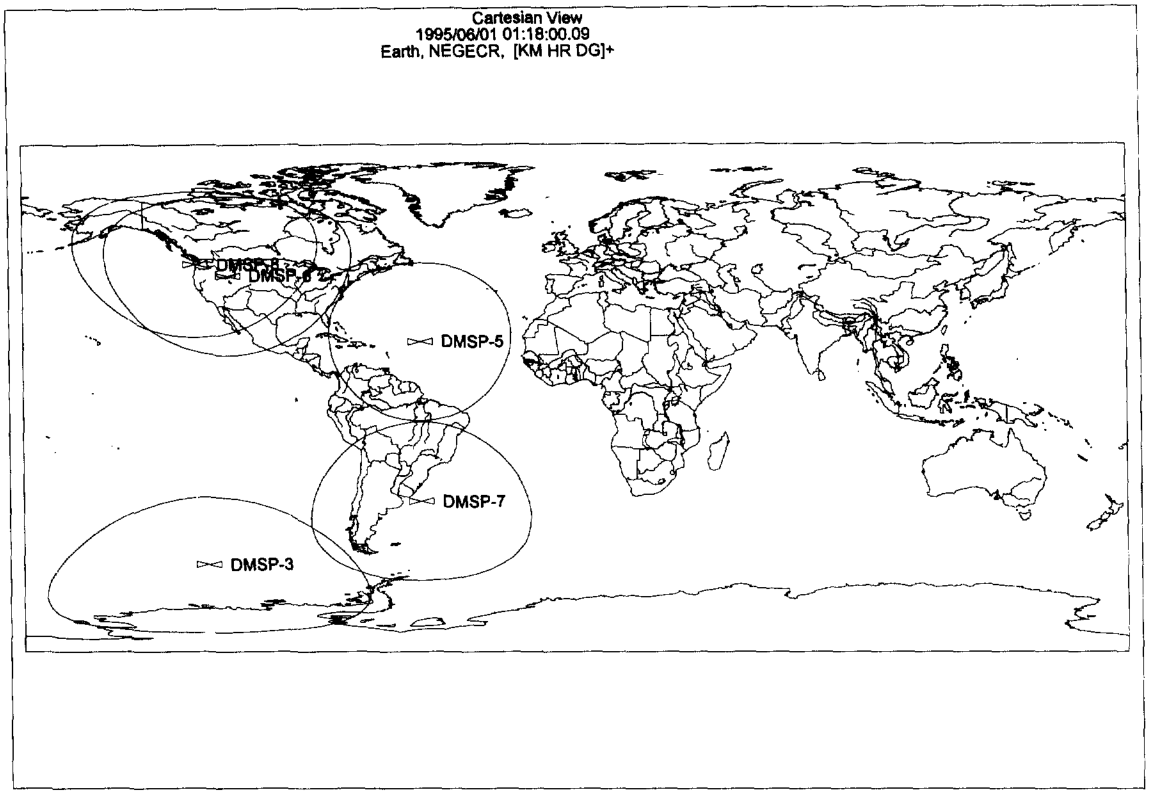

Figure 14. DMSP Coverage Footprint For 0 Degree Elevation.

Figure shows the impact of the DMSP protection coverage on Leo One USA Availability. The top curve shows the availability of the Leo One USA constellation for a 15 degree coverage zone assuming no frequency conflicts. This availability is by design 100 percent over CONUS. The availability drops to 84 % for 10° DMSP coverage protection. At 5° DMSP protection coverage the availability drops to 77 % while for 0° DMSP protection coverage the Leo One USA availability drops to 68 percent. Even for 5° DMSP protection, the 77 percent availability impacts planned services.

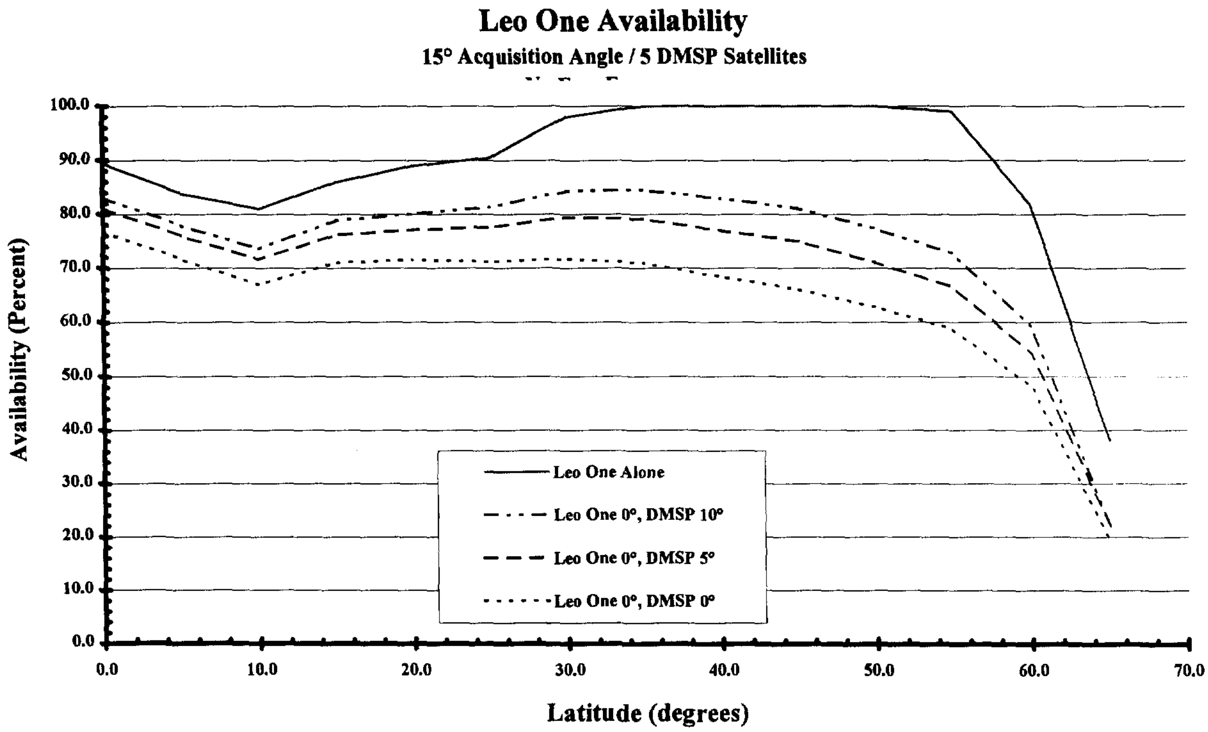

Figure 15. Leo One USA Availability For 0, 5 and 10 Degree DMSP Coverage With 0 Degree Leo One USA Coverage Avoidance.

B. NVNG MSS System Testing Requirements

The requirement for testing the systems ability to change downlink frequency within 90 minutes in these bands up to four times a year seems excessive, arbitrary and an unnecessary imposition to the operation of a commercial communication systems. Once a year would seem more than adequate under the supposition that the DoD wishes "to ensure that the system operator can implement the frequency change and that there are no equipment or system based problems in doing so".

It should be noted that for a constellation such as Leo One USA, that frequency changes will be continually required as satellites approach the radio horizon of a DMSP satellite as described in our comments to Paragraph 70. This requirement results since each DMSP band individually does not support the entire spectrum requirements of Leo One USA's downlinks. Thus, as a Leo One USA satellite horizon approaches the DMSP footprint operating in the same band, it must change to the opposite frequency band. In so doing, it must temporarily select a frequency that is not in use with any other Leo One USA satellite that also overlaps its radio horizon. At times there can be up to nine other Leo One USA satellites in contact with any given Leo One USA satellite's horizon coverage footprint. This is not a problem to Leo One USA under normal circumstances since different frequencies are assigned to each orbit plane. Ordinarily any required frequency changes are planned well in advance so the entire constellation frequency plan will change at the same time using stored commands. Immediate changes as stations contact a command site will lead to conflicts that could preclude normal operations in Leo One USA coverage overlap regions.

We also note that assuming the DMSP frequency assignment change requirement arises naturally from real world operational requirements, it would seem it would be executed occasionally during normal military operations and, thus, not need to be tested at random so frequently. We would propose to require at most an annual test during those years when an operational change has not occurred, and preferably not during peak traffic periods over principal market areas.

The operational motivation for unscheduled frequency changes is not clear, except in response to an abrupt on set of local interference in some geographic area. Overlapping DMSP footprint coverage can be predicted long in advance and frequency changes regularly scheduled and coordinated with an NVNG satellite Constellation Operations Control Center (COCC). We also suspect that if intentional jamming were the motivation for changing frequencies, the proposed frequency change would be totally ineffectual. A jammer could quite easily monitor the bands for the downlink and instantaneously jam the channel or, alternatively, it could jam both channels simultaneously as satellites enter its horizon.

It is possible the interference may only become apparent one rev in advance of the satellite coverage for a given area and the DoD space command network is capable of responding within that period. However, this would seem to be a rare event. For such a rare event a requirement to have a world wide network of terrestrially interconnected command stations for a commercial NVNG system is a significant burden.

C. 90 Minute Command Station Requirements

While it is theoretically possible to command the entire Leo One USA satellite in 90 minutes, a world wide network of command stations is required. Leo One USA did not intend to locate command stations outside the U.S. In particular, we did not intend each international gateway to have a satellite command capability. We believe a network of command stations operated within CONUS can provide a response time of less than 11 to 14 hours for orbit inclinations of approximately 50 degrees. A network of command stations operated from U.S. Soil can reduce this to under 8 hours. Additional command stations in foreign locations are necessary to reduce this to meet a 90 minute command time. In general, it is very difficult to command a constellation in less than its orbital period. For Leo One USA, its orbital period is approximately 104 minutes. A command requirement of the order of 104 minutes results in a more economically satisfactory solution. We believe a "one orbital period" requirement is the most reasonable approach to satisfying this DoD requirement together with a 15 minute command generation time allowance

It is possible to create a "fence" of four ground stations extending from North America through South America that can guarantee contacting every satellite in the constellation over one orbit period. However, since an orbital revolution takes about 104 minutes, some satellites, will not be seen in 90 minutes or less.

Given no warning, and with automated command generation software, it is estimated that it may take 10 to 15 minutes for the command streams to be generated and transmitted to the appropriate remote command stations. This assumes the only inputs required in real time are the new frequency bands in use by up to five DMSP satellites. Thus, realistically, this leaves not 90 minutes to recommand the satellite network, but 75 to 80 minutes to meet the DoD requirement. We believe a "one orbital period" requirement is the most reasonable approach to satisfying this DoD requirement together with a 15 minute command generation time allowance which would result in a 120 minute response time.

The costs of generating and validating this software, while not insignificant, are minor compared to the total network operations software requirements. Likewise, it is anticipated that dedicated leased lines or VSAT networks will be required to link the COCC and the remote command sites.

D. Transitional Interference Statistics

The commission has requested statistics of the interference created to a DMSP ground station from the time a DMSP satellite would change frequency band segment to the time all the Little LEO satellites could be re-commanded. This is a multidimensional problem, complicated by the potential world wide DMSP user locations and Little LEO command sites. In order to address these statistics, we have first assumed that a DMSP satellites is re-commanded while in view of Sunnyvale, CA. We have then considered two cases, the command station "Fence" sites consisting of San Diego, Miami, Sinnamary (French Guinea), and Santiago (Chile) and the "90 minute" site locations defined by Seattle, Miami, Valdiva, Tokyo and Melbourne. We have also assumed that the initial frequency assignments made to Leo One USA satellites were such that they would not interfere with the DMSP satellite. This implies that after the DMSP frequency change, every Leo One USA satellite that comes in contact with the DMSP satellite will cause interference since it will now be on the wrong frequency.

Since the frequency change will be completed within an orbital period, over much of this time, the Leo One USA satellites will be interfering with the DMSP satellite. It should also be noted that this interference, in general, does not extend over the entire DMSP coverage footprint. Thus, many users would still receive DMSP downlinks interference free. Further, for any individual DMSP user station, this interference would only occur once. Averaged statistics of interference to a single user are therefore difficult to interpret if not somewhat meaningless.

Figure shows the DMSP and Leo One USA satellite ground traces for one Leo One USA orbital period (104 minutes) that were used for this evaluation. Figure 17 shows the Leo One USA satellites in contact with this DMSP satellite over an orbital rev. The satellites are numbered sequentially from 1 to 48 starting from the first satellite in plane one. The contact time is computed for a 5 degree DMSP coverage to a horizon coverage Leo One USA footprint. We believe this is a reasonable worse case situation in that the DMSP satellite is in a retrograde orbit moving north and west away from the Leo One USA satellites that are re-commanded at the start of this simulation. It takes approximately half a rev before the DMSP satellite contacts the recently commanded Leo One USA satellites which are moving eastward. Since Leo One USA's horizon coverage is 100 percent between approximately ±70° latitude, the DMSP satellite can only operate interference free to high latitude (polar) ground stations until the satellites are re-commanded.

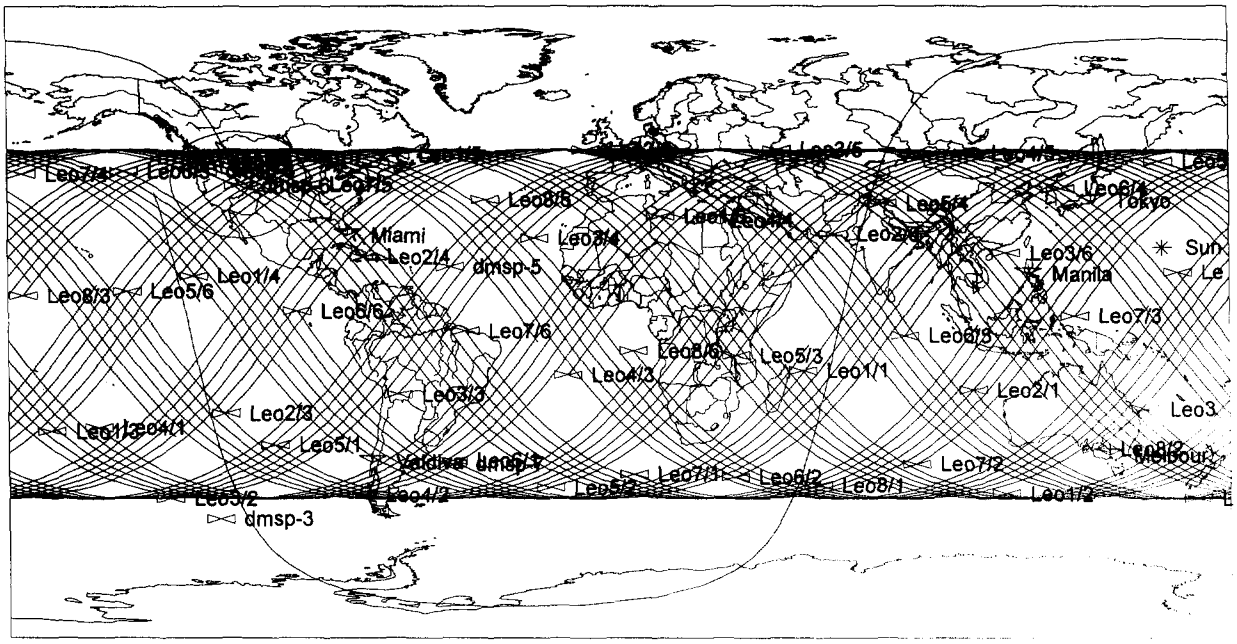

Figure 16. DMSP and Leo One USA Ground Traces.

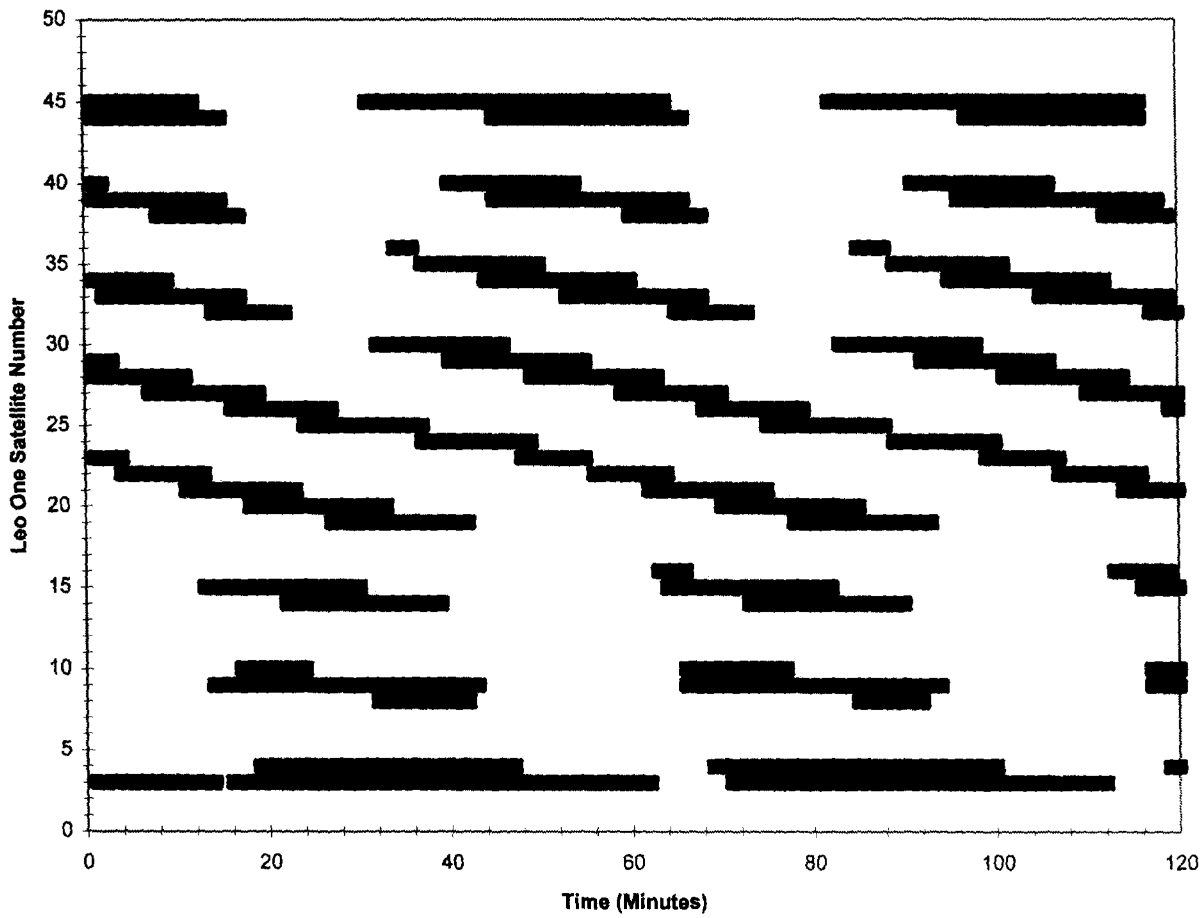

Figure 17. Leo One USA satellites In Contact With DMSP Satellite.

2.D.2. "Fence" Site Results

Figure 18 shows the Leo One USA satellite command times for a minimum 10° elevation angle. This figure starts from the DMSP Sunnyvale contact time and assumes commanding of the Leo One USA satellites begins immediately as they contact the command stations along the "fence".

Figure 19 shows the timeline for footprint overlap conflicts as a function of time. As indicated, after approximately 55 minutes half of the satellites have been commanded to their new frequency assignments. Only 8 satellites cause interference after 55 minutes. The last satellite conflict ceases at 94 minutes. After 104 minutes all satellites have been commanded to new frequencies and all possible conflicts cease.

Figure 20 through Figure 25 shows the extent of the DMSP coverage footprint overlap each 20 minutes over this one rev period. The DMSP coverage is shown as 5° and the Leo One USA coverage is shown as 0°. As indicated, the loss in coverage area for the DMSP satellite shrinks dramatically after approximately 55 minutes, or approximately one-half the Leo One USA orbital period. However for the worse case situation, the sun synchronous retrograde orbit maintain a conflict as a result of its polar and westward motion. If the satellite had been commanded on its downward leg approximately 12 hours later, this situation would have been less severe.

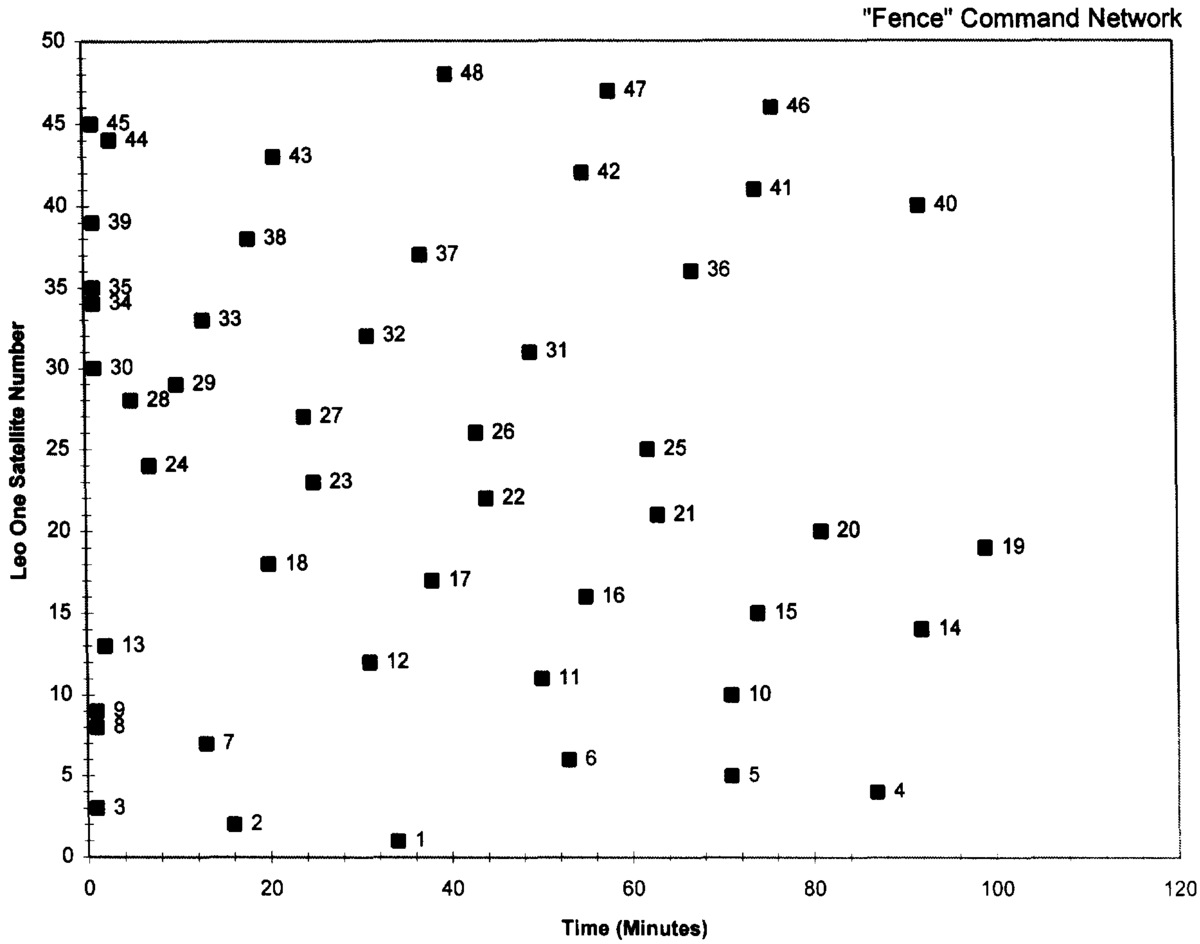

Figure 18. Leo One USA Satellite Command Times Over a 104 Minute Period With "Fence" Command Sites.

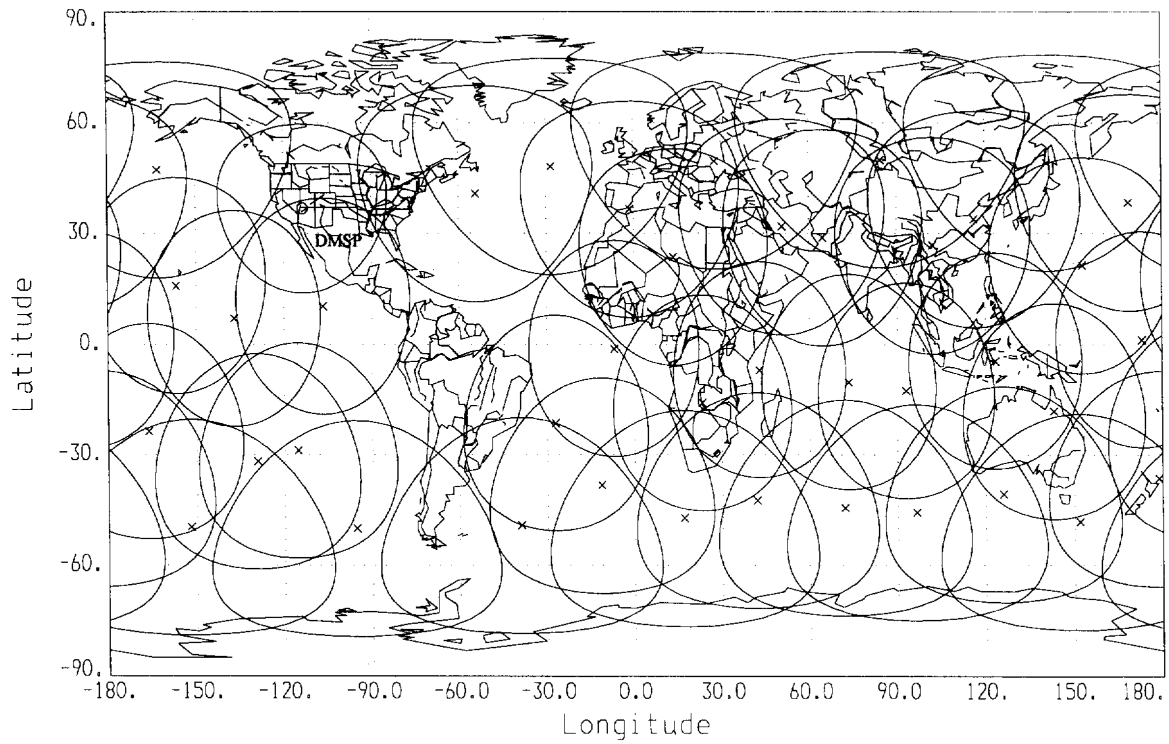

Figure 20. Leo One USA Interference Footprint Overlaps With DMSP At 0+ Minutes.

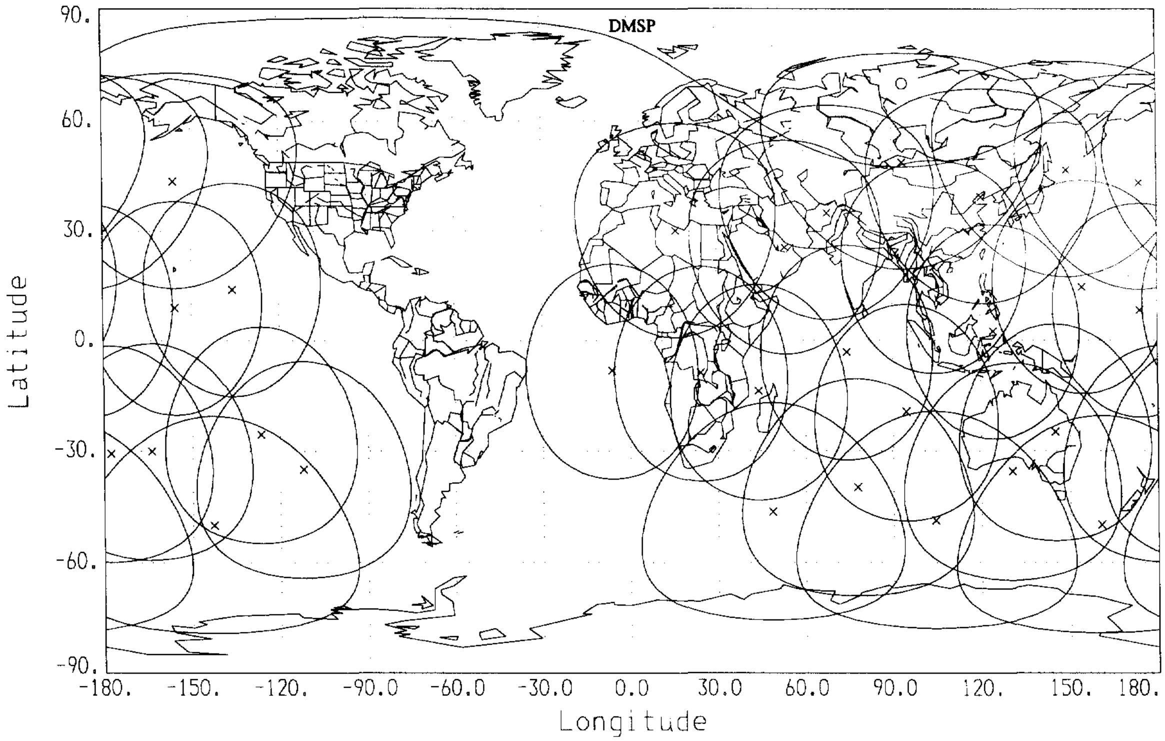

Figure 21. Leo One USA Interference Footprint Overlaps With DMSP At 20 Minutes.

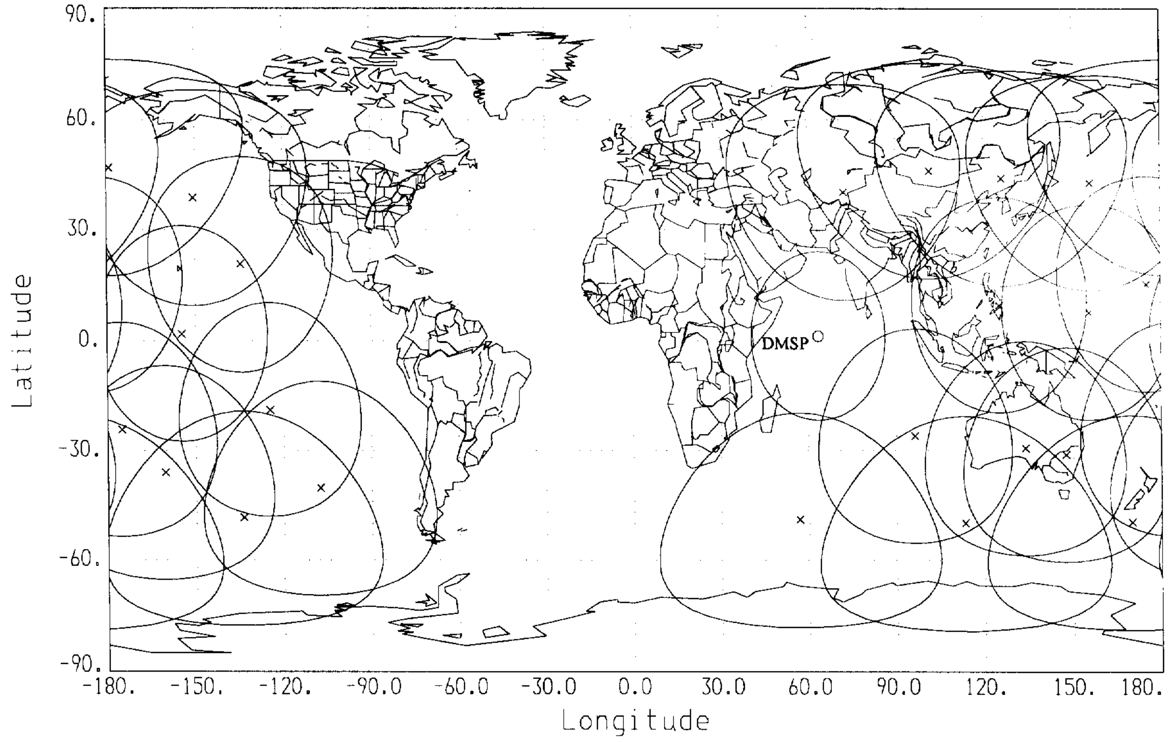

Figure 22. Leo One USA Interference Footprint Overlaps With DMSP At 40 Minutes.

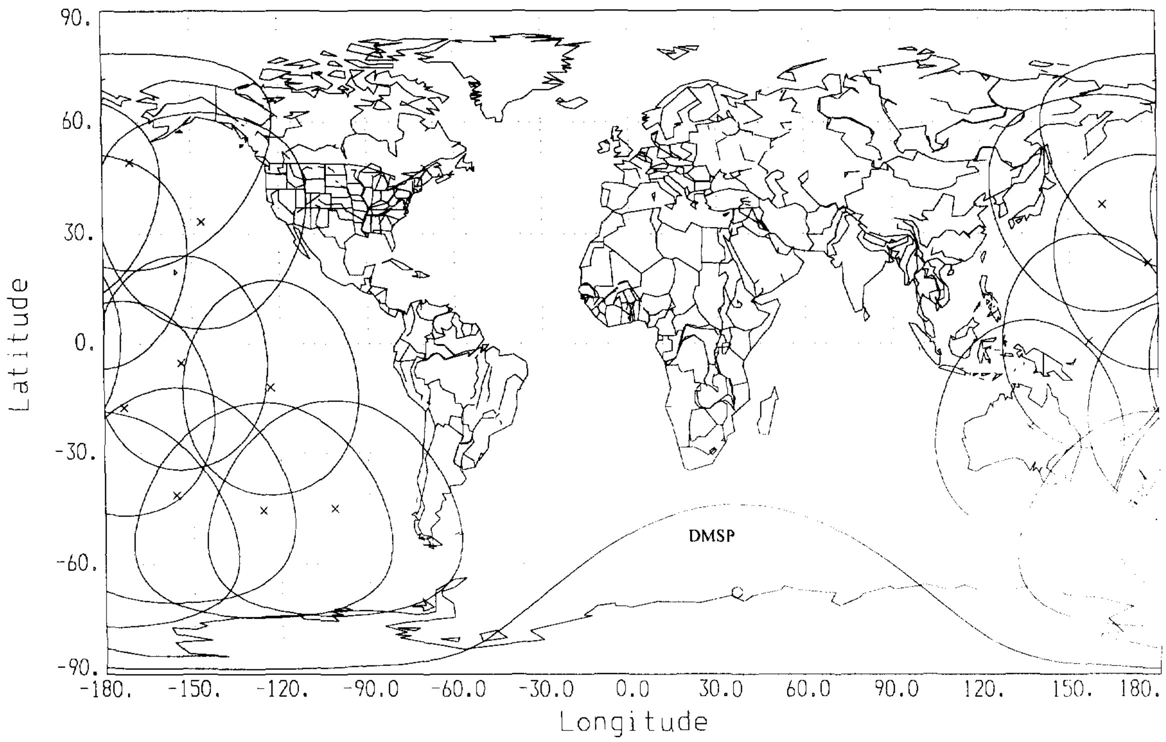

Figure 23. Leo One USA Interference Footprint Overlaps With DMSP At 60 Minutes.